Analysis of Reactive Processes in a CO2 Pilot Injection Test

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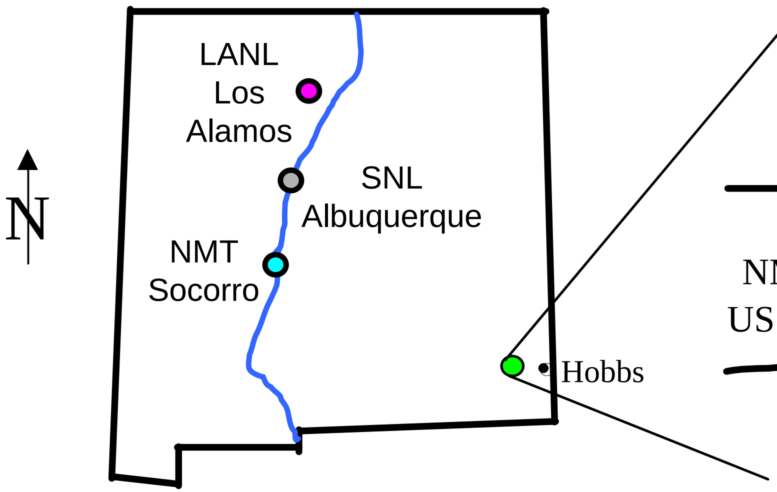
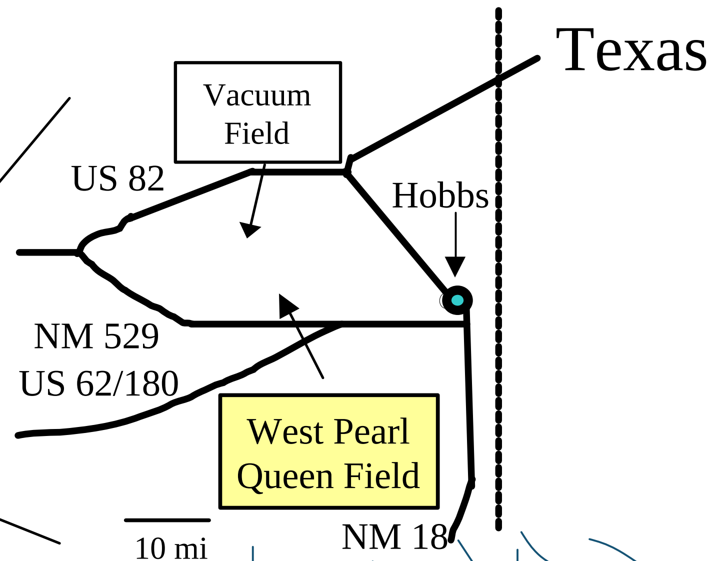
Outline

- Background
- Self-Trapping Concept
- Objectives
- Dawsonite Precipitation Timing study
- Conclusions
- Acknowledgements

West Pearl Queen Reservoir





Bulk Mineralogy

67% Quartz

23% Albite

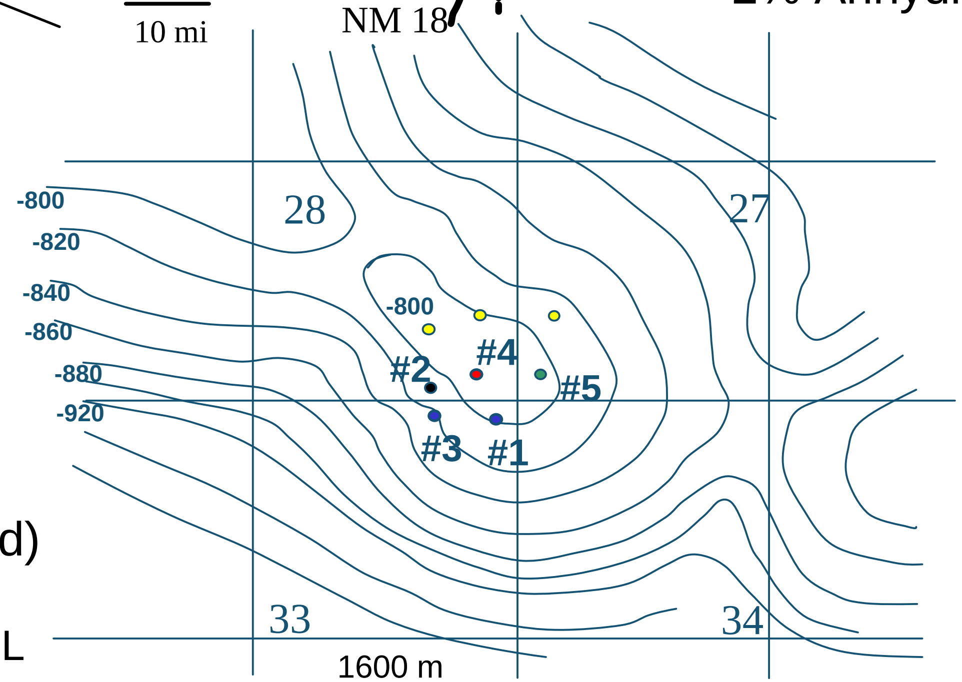
5% K-Feldspar

2% Dolomite

2% Anhydrite

Strata Production Co. Wells

#4	CO_2 Injection & monitoring well
#5	Monitoring & producing well
#1&3	Waste water injector well
#2	Plugged well

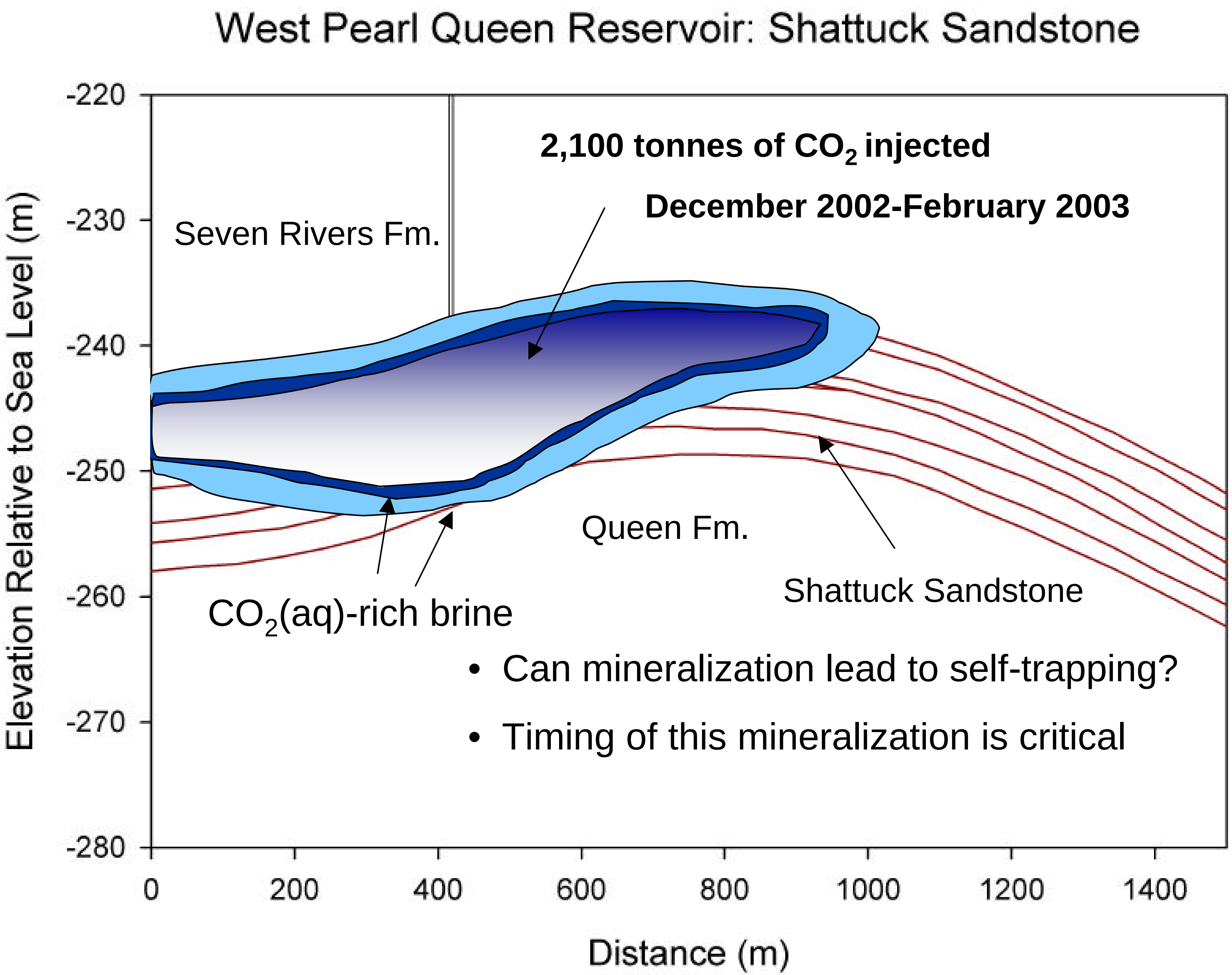


Brine composition:

180,000 mg/L (NaCl-dominated)

Figure compliments of R. Pawar, LANL

Self-Trapping Concept



- Can mineralization lead to self-trapping?
- Timing of this mineralization is critical

Dawsonite

- Naturally occurring throughout regions of the world with CO_2-rich waters, but has not been reproduced within laboratory experiments

Specifically…..

- Springerville Natural CO_2 Field (eastern AZ) (Moore et al., 2003)

- Bowen-Gunnedah-Sydney Basin (Australia) occurs as a widespread cement within sedimentary rocks (Baker et al., 1995)

- Ordovician limestone of Montreal, Quebec occurs as sills (Vard, 1993)

Objectives

- Determine specific geochemical reactions that proceed within the reservoir
- Examine propensity for self-trapping (Dawsonite precipitation)

Tools…..

- TRANS (Lichtner, 1999)
- Geochemist's Workbench (Bethke, 2002)

- Examine timing of Dawsonite precipitation
  - What is controlling this time scale?
  - How are other reactions enhancing or prohibiting Dawsonite precipitation?

Objectives

Geochemical Rxns. at high CO_2(aq) concentrations

pH = ~4.7

Dissolution processes

CO_2(aq) = ~1 molal

Albite dissolution

(1) $$KAlSi_3O_8 + 4H^+ \leftrightarrow 2H_2O + Na^+ + Al^{3+} + 3SiO_2(aq)$$

K-Feldspar dissolution

(2) $$NaAlSi_3O_8 + 4H^+ \leftrightarrow 2H_2O + Na^+ + Al^{3+} + 3SiO_2(aq)$$

Anhydrite and Dolomite dissolution

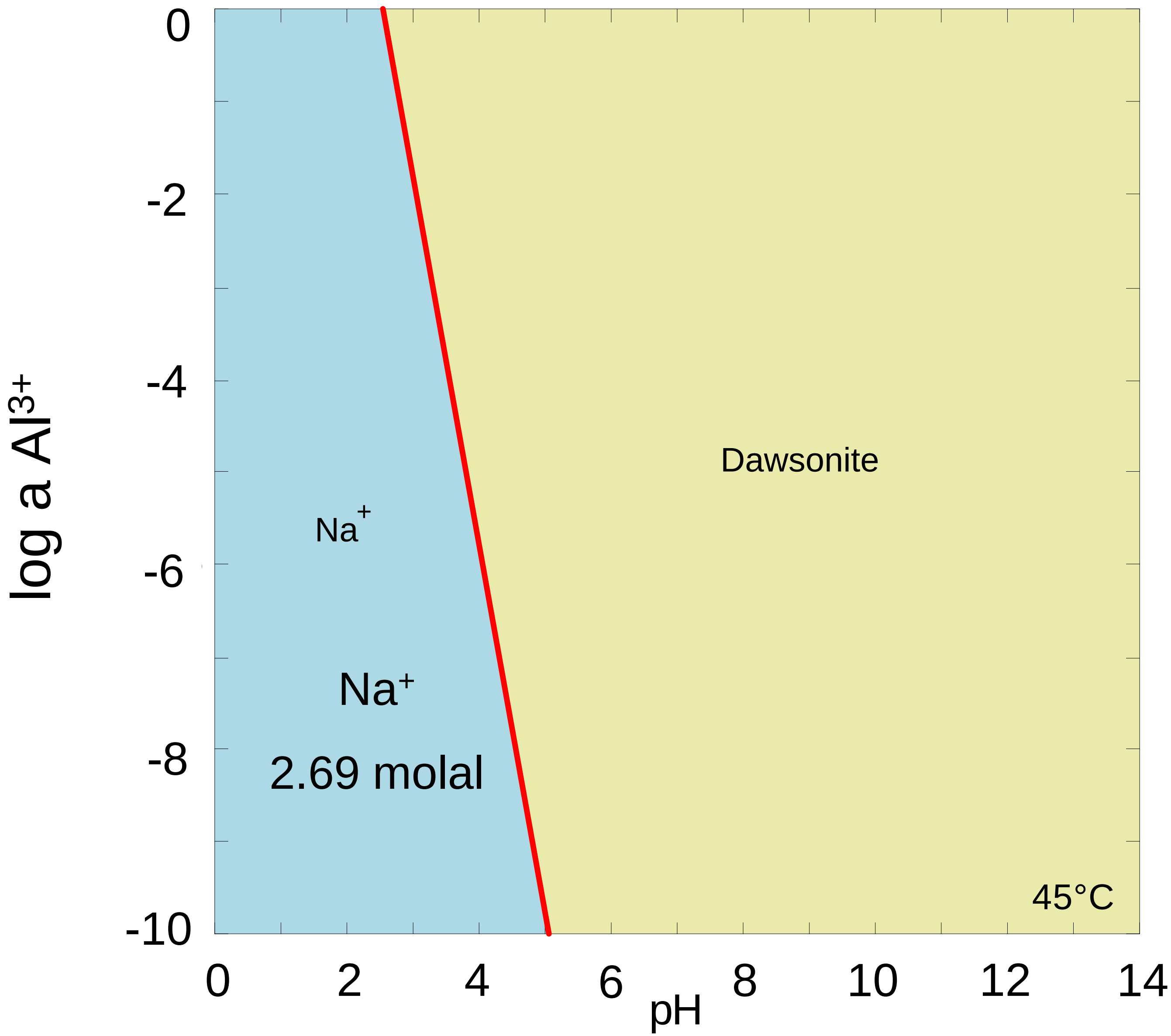
Major Mineralization processes

Dawsonite precipitation

(3) $$NaAlSi_3O_8 + CO_2 + H_2O \leftrightarrow 3SiO_2(aq) + NaAlCO_3(OH)_2$$

Objectives

At what conditions is Dawsonite stable?



Objectives

Parameterization of kinetic rate constants

Study	K-Feldspar (mol/cm^2-s)	SSA (cm^2/g)	Albite (mol/cm^2-s)	SSA (cm^2/g)	Dawsonite (mol/cm^2-s)	SSA (cm^2/g)
1	1.62×10^{-13}	711	3.63×10^{-13}	695	1.38×10^{-11}	849
2	1.00×10^{-16}	**	1.00×10^{-16}	**	1.00×10^{-16}	**
3	1.78×10^{-14}	**	**	**	1.00×10^{-11}	**
4	1.00×10^{-17}	300*	1.00×10^{-16}	600*	1.00×10^{-16}	300*

Notes: 300* = Specific surface area in (cm^2/cm^3) per bulk volume

** = no data available

1: Gauss et al. (2003)

2: Xu et al. (2002)

3: Johnson et al. (2001)

4: Stauffer et al. (2003)

Timing Study

Sensitivity Analysis to determine time scale for Dawsonite precipitation

Sensitivity Analysis: kinetic rate constants varied while holding specific surface areas constant (set to Gauss et al. (2003))

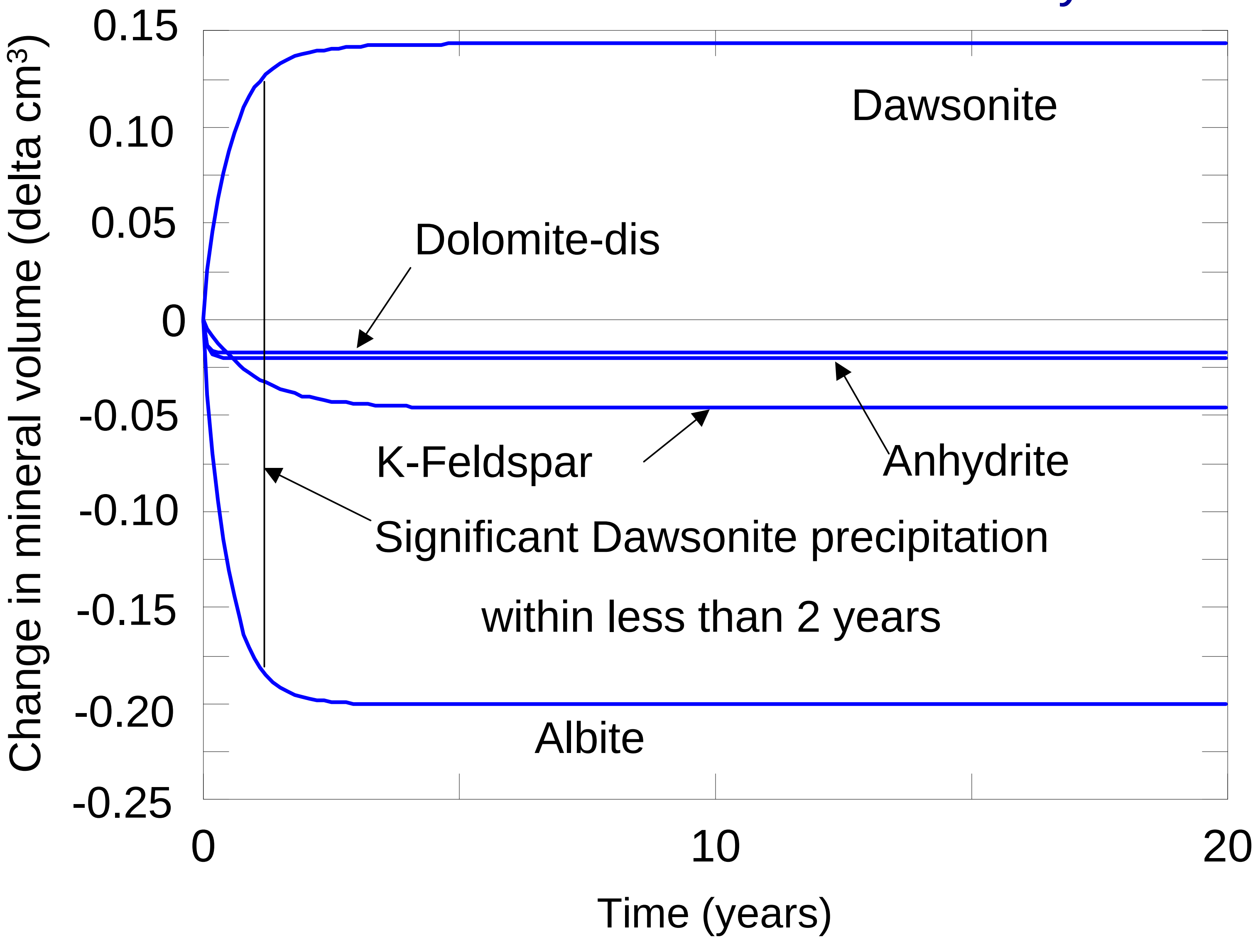
Gauss et al., 2003 parameters were used as base case

- varied K-Feldspar, Albite, and Dawsonite rate constants
- examined the timing of Dawsonite precipitation

Study	Timing
Gauss et al.	<2 yr
Xu et al.	~800 yr
Johnson et al.	~1000 yr
Stauffer et al.	~3000 yr

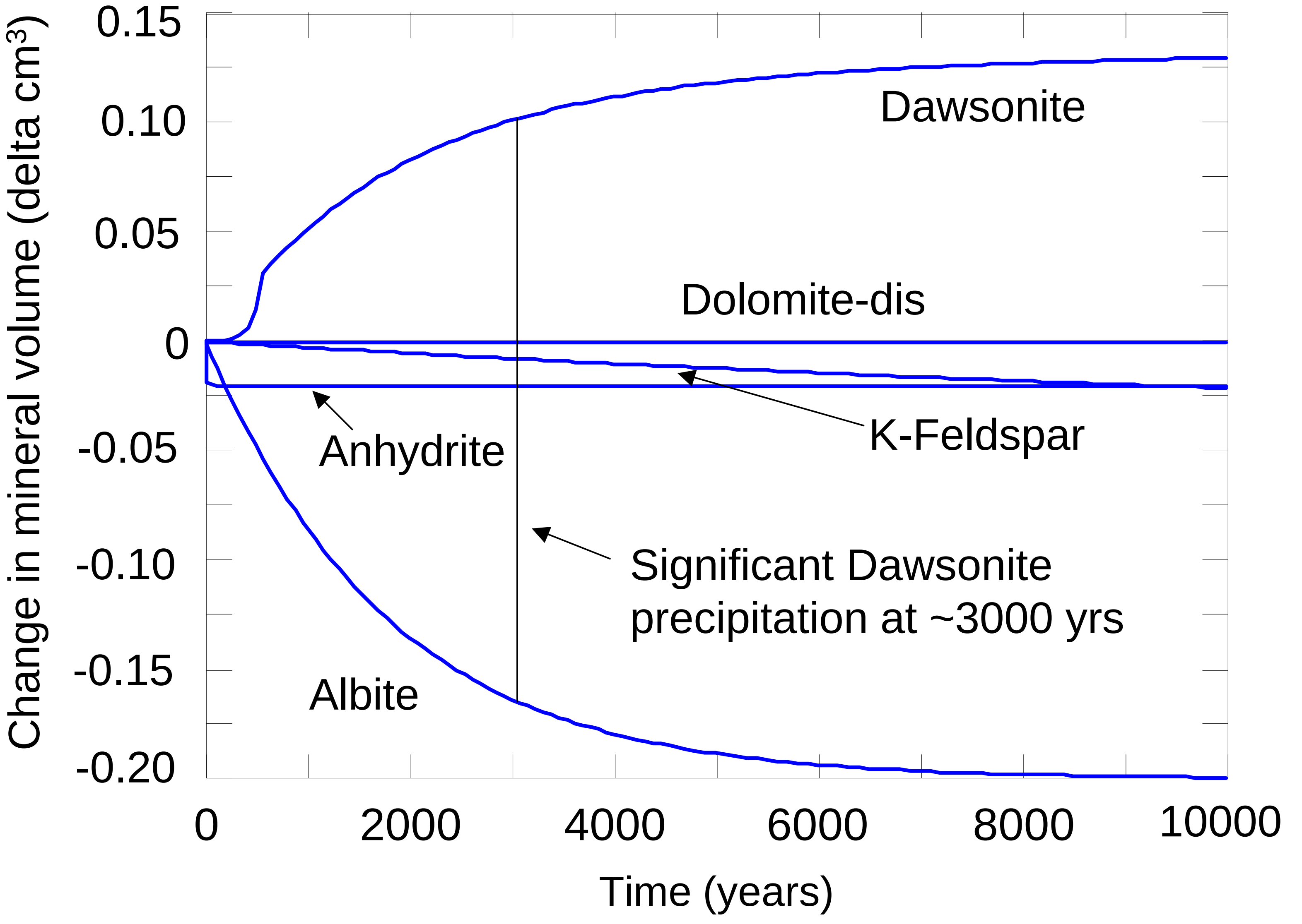
Timing Study

Fast kinetic rate constants: Study 1



Timing Study

Slow kinetic rate constants: Study 4



Timing Study

Controls on timing of Dawsonite precipitation

- Timing of Albite dissolution (rate constants)
  - Albite dissolution controls Al^{3+} in solution which in turn controls Dawsonite precipitation

- Kinetic rate constants of alumino-silicate minerals and of Dawsonite control the precipitation timing

- Precipitation timing varies over several orders of magnitude due to kinetic rate constant disparities

Conclusions

- Dawsonite precipitation at high CO_2(aq) concentrations is predicted in an arkosic sandstone reservoir

- Timing of Dawsonite precipitation varies over several orders of magnitude mainly dependent upon the kinetic rate constants of feldspathic minerals and Dawsonite

West Pearl Queen Implications

- Self-trapping may occur if separate phase CO2 remains in the vicinity of feldspar-rich mineral zones (in the case of the West Pearl Queen reservoir, Albite)

- Dawsonite may greatly influence reservoir hydrodynamics due to porosity and permeability changes

- Sites with feldspar rich cap rocks provide the best opportunity for Dawsonite self-trapping

  - Overlying mineralogy within the West Pearl Queen reservoir is dominated by evaporitic minerals

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